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DSM Power Plant in India ☆

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A B S T R A C T

India is facing acute energy shortage that is likely to affect its economic development. There are severe supply side constraints in term of coal and gas shortages that are likely to continue in the near future. Hence, in its current focus to solving the energy shortage problem and sustaining the development trajectory, the country should aim at a balance between supply side and demand side measures. Energy Efficiency in end use is increasingly gaining importance as one of the most cost effective options for achieving short to medium term energy savings. India has initiated the National Mission for Enhanced Energy Efficiency under National Action Plan for Climate Change which addresses various aspects of energy efficiency such as technology, financing, fiscal incentive and also creation of energy efficiency as a market instrument. However, even though energy efficiency has substantial scope in the Indian subcontinent, the market for energy efficiency has been limited. This paper discusses the concept of mega Demand Side Management projects as a DSM Power Plant. A DSM Power Plant acts as an umbrella with multiple energy efficiency schemes under its ambit aimed at transforming energy efficiency into a business by providing a push to the scale of operation as well as financial sustenance to energy efficiency projects. This paper expounds on the various aspects of DSM Power Plant in terms of its policy and institutional mechanism for the large scale implementation of energy efficiency in India. This paper provides an illustration of the concept of DSM Power Plant model through a case study in one of the states (Rajasthan) of India. Further, a comparative analysis of the cost of generation from DSM Power Plant and a representative conventional power plant (CPP) in Rajasthan has been undertaken and the DSM Power Plant comes out to be a more cost effective option. The concept of DSM Power Plant will not only address the issue of energy shortages but will also help the financially thwarted utilities to reduce their revenue deficit in the near future.

Contents

1. Introduction . . . 538
2. Synergy of energy efficiency with renewable energy (RE) . . . 538
3. Energy efficiency programmes in India . . . 539
4. Barriers to implementation of energy efficiency in India . . . 539
5. Concept of DSM Power Plant . . . 540
6. International experience . . . 540
7. Lessons learned for India . . . 540
8. Proposed framework for DSM Power Plant in India . . . 541
   8.1. Objectives of the framework . . . 541
   8.2. Working of the DSM Power Plant in the Indian setup . . . 541
   8.3. Framework of the proposed model . . . 542
      8.3.1. Step I- State level energy efficiency resource assessment . . . 542

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8.3.2. Step II- State energy efficiency policy and DSM Regulations . . . 543
8.3.3. Step III-Formation and identification of energy efficiency package . . . 543
8.3.4. Step IV-Selection of bidder . . . 543
8.3.5. Step V-Energy service contract . . . 543
8.3.6. Step VI-Monitoring and evaluation . . . 543
8.4. Sustainability of the model . . . 543
9. Case-study—implementation of a DSM Power Plant in Rajasthan. . . . 543
9.1. Overview of Rajasthan power sector . . . 543
9.2. Need for energy efficiency in Rajasthan . . . 543
9.3. Framework of DSM Power Plant in Rajasthan . . . 544
9.3.1. Institutional framework . . . 544
9.3.2. Generation from the DSM Power Plant . . . 544
9.3.3. Computation of capital cost . . . 544
9.3.4. Impact of the DSM Power Plant on distribution utilities of Rajasthan. . . . 545
10. Conclusion . . . 546
Acknowledgments . . . 547
References . . . 547

1. Introduction

Sustainable economic development, environmental concerns, energy security are some of the important drivers for improving energy efficiency in India. India's economy has been growing rapidly over the last decades and is projected to grow at a much faster rate than that of Europe or the United States during the coming four decades [1]. In order to sustain this high growth India faces a formidable challenge in meeting its energy needs especially electricity.

Although the Indian Power sector has considerably improved its generating capacity, it still has difficulty in meeting demand and there are persistent power shortages which constraint its economic growth. According to the International Energy Agency, in 2008, more than 400 million people did not have access to electricity in India [2]. In 2011–12, overall energy shortage and peak power shortage in the country stood at 8.5% and 10.6% respectively [3]. Shortages in power supply are due to consistent shortfalls in the capacity addition achieved vis-à-vis the targets in every Plan period [4].

In this context, the Government of India (GoI) has taken several steps to move along a path of higher energy efficiency. The GoI institutionalized energy efficiency through the Energy Conservation Act, 2001 (EC Act, 2001) under which a statutory authority; the Bureau of Energy Efficiency (BEE) was formed. At the central level, BEE is responsible for implementation and coordination of energy conservation activities in the country as per the provisions of EC Act, 2001. The aim of the BEE has been to institutionalize energy efficiency services by developing policies and strategies with a thrust on self-regulation and market principles, within the overall framework of the EC Act, 2001, in all sectors of the country in order to reduce energy intensity in the economy. Besides, this, the EC Act 2001 has also mandated the state government to designate an agency in the state to carry out activities of energy conservation at the state level as per the provisions of the Act. The state designated agency, designated by the state government is responsible for coordinating, enforcing and regulating matters related to the implementation of the EC Act, 2001. Further, Section 61 (C) of Electricity Act 2003 requires state electricity regulatory commissions (SERC's) to set tariff by considering factors which encourage competition, efficiency, economical use of resources, good performance, and optimum investments within the state. Under this provision, SERC's can direct the electricity utilities to undertake demand side management (DSM) activities. Further, National Electricity Policy and National Tariff Policy have also provided impetus to promotion of energy efficiency.

The policy umbrella for energy efficiency in India has been widened with the introduction of National Mission for Enhanced Energy Efficiency (NMEEE) under the National Action Plan on Climate Change. NMEEE laid emphasis on taking up four new initiatives, which include market-based mechanisms to enhance cost effectiveness, accelerating the shift to energy-efficient appliances, financing demand side management programmes in all sectors by capturing future energy savings, and developing fiscal instruments to promote energy efficiency [5]. As a result of the implementation of this mission, it is expected that over the five year time period about 23 million tons of oil equivalent of fuel savings in coal, gas and petroleum products will be achieved along with an expected avoided capacity addition of over 19,000 MW. As a consequence carbon dioxide emission reduction is estimated to be 98.55 million tons annually [6].

As per the Integrated Energy Policy of the Planning Commission, the electricity saving potential of demand side on India is about 15% of the total electricity demand.The study undertaken by National Productivity Council for Bureau of Energy Efficiency in 2009–10 highlighted a combined saving potential of 75.4 billion kWh per year in various sectors which was more than the overall annual energy deficit of 73.1 billion kWh reported during 2007–08. As per this study, the estimated annual potential of energy efficiency in various sectors is provided in Table 1 [7].

2. Synergy of energy efficiency with renewable energy (RE)

The efforts to promote energy efficiency have also become important for increased penetration of RE in the country. There lies a significant potential of RE in India and to harness this potential several initiatives has been undertaken by the GoI. The Electricity Act 2003, National Electricity Policy and National Tariff Policy have placed special emphasis on the promotion of RE. Further, National Action Plan on Climate Change (NAPCC) set the

Table 1
Sector wise annual energy efficiency potential in India.

Sector	Potential (%)
Agricultural pumping	30
Commercial buildings/Establishments with connected load >500 kW	20
Municipalities	23
Domestic	20
Industry (including SMEs)	7
All India	15

target RE purchase at 5% for FY 2009–10 with the target increasing by 1% for next 10 years. Further, it is expected that most of this power will operate in grid connected mode. Large scale grid integration of intermittent sources of power leads to problem in grid operation.

In this context, it becomes important to promote the concept of demand side management which includes the concept of demand response. For e.g. In case of sudden reduction in the generation of wind, grid operator requires immediate flexible generating resources for balancing power in the grid. Variation/reduction in demand could act as an important resource for balancing power in the grid as it has the high ramp down time. Thus, promotion of effective demand response mechanism can play an important role in balancing power in the grid and promoting RE in the country.

3. Energy efficiency programmes in India

There are various agencies which are responsible for undertaking energy conservation activities in the country. In line with the EC Act 2001, BEE has initiated various schemes for promoting energy efficiency in India. The schemes of BEE include Standard and Labeling programme (S&L), Energy Conservation and Building Code (ECBC), Bachat Lamp Yojana (BLY), Agriculture DSM and Perform, Achieve and Trade (PAT). Some of these schemes are briefly described in the Table 2 [5,8,9,11].

At the state level, various initiatives have been undertaken by the utilities to promote energy efficiency in the form of replacement of inefficient appliances with the efficient ones. These programmes have been majorly targeted towards replacement of ICLs with CFLs and more recently towards replacement of ACs and refrigerators.

Further, in order to provide regulatory framework to DSM, various states such as Gujarat, Maharashtra, Himachal Pradesh have drafted DSM Regulations for undertaking planning, designing, and implementation of DSM programmes on a sustained basis.

4. Barriers to implementation of energy efficiency in India

Although energy efficiency in India has improved over the last decade, and energy intensity has declined by about 20–25% [10], there are avenues where energy efficiency opportunities continue to exist largely because of a number of policy, institutional, cost and information related barriers that inhibit large scale adoption of energy efficient technologies in India [11] and these barriers are detailed out below:

i. Distorted Pricing Mechanism of electricity: lack of appropriate pricing signals often result in wasteful usage of electricity particularly by subsidized consumer categories. In India, for instance, residential and agriculture sectors are being either subsidized or cross subsidized by industrial and commercial sectors.
ii. High initial cost of energy efficient appliances: energy efficient appliances are generally costly and entail high upfront costs, which act as a deterrent to their sale. Also, life-cycle cost of the appliances is not factored in by the consumers while purchasing energy efficient products.
iii. Lack of availability of energy efficient appliances in the local market: low demand for energy-efficient products, provide no incentive to local dealers and retailers to stock such products.
iv. Low level of awareness on part of both consumers and electricity utilities: consumers are not aware about the available energy efficiency options and the benefits that can accrue to them through adoption of these options. At the same time utilities are not aware of the fact that by promoting energy efficiency measures significant cost reductions can be obtained through less purchase of costly power during peak hours.
v. Lack of financing options: energy efficiency is considered a notional concept with no upfront tangible outputs. Thus, financial institutions are generally averse to financing energy efficiency related investments.
vi. Lack of incentive for the utilities: the cost plus tariff regime does not offer adequate inducement or incentive to the utility for carrying out DSM measures.
vii. Deteriorating financial condition of the utilities: deteriorating financial condition of the state owned utilities is a major reason that inhibits utilities to undertake DSM. As per a report published by Power Finance Corporation (PFC), during the year 2009–10, the utilities incurred combined losses of $ 12 billion (without accounting for subsidy) [12].
viii. Problem of split incentives: energy efficiency opportunities are likely to be foregone if actors cannot appropriate the benefits of the investment. The split incentive issue is a typical principal agent problem, in which the investor does not reap the rewards of improved efficiency. For instance, in this situation, the landlord (agent) buys and supplies all of the components of a potentially energy efficient apartment or home which includes appliances such as refrigerator, air conditioning, fans, etc. The landlords incentive is to supply

Table 2
Energy efficiency schemes in India.

BLY	This scheme involves the replacement of Incandescent Lamps (ICL) with Compact Fluorescent Lamps (CFL) in domestic households. Under the scheme CFLs are provided at the cost of ICLs by investors who in turn receive carbon credits. The investor led projects are registered under CDM under the Programme of Activities as a part of UNFCCC. As per BEE estimates, there are over 400 million light points in India using incandescent lamps which if replaced with CFLs would reduce approximately 6000 MW of electricity demand in the country.
S&L	Labeling has been introduced for 16 major energy consuming appliances, providing users with information on energy use and relative energy efficiency of the appliance. In 2010–11, S&L programme resulted in electricity saving of 3718 GW h, equivalent to avoided capacity generation of 2162 MW.
ECBC	Energy conservation building code sets minimum energy performance standards for the design of new commercial building. Further, performance contracting through Energy Saving Companies (ESCOs) is being promoted to enable retrofit of existing building to reduce their energy consumption. In 2010–11, implementation of ECBC resulted in electricity saving of 23 GW h, equivalent to avoided capacity generation of 4 MW.
PAT	Highly energy intensive industries have been identified as designated consumers (DCs) for the reduction of specific energy consumption as per the prescribed targets by 2014–15. The DCs over achieving their target would be entitled to energy saving certificates, thus providing a market for energy efficiency. This scheme provides for an energy saving potential of 6.68 million toe/year at the end of first phase of PAT Cycle (2012–2015).
Agriculture DSM	Under this scheme, pump set energy efficiency up gradation would be carried out through public private partnership mode. The implementation of the first pilot at Solapur district in Maharashtra has commenced and as of March 2012, 1200 pumps have been replaced in Solapur region.

these at the lowest possible cost (not the highest efficiency), because he does not pay the energy or utility bills [13].

In order to address some of these barriers and accelerate the energy efficiency market in the country, it is required that a different approach be adopted for implementing DSM in India. This paper discusses the concept of mega DSM projects as a DSM Power Plant that addresses the above discussed barriers that India has been facing that has deterred the large scale implementation of energy efficiency in India.

5. Concept of DSM Power Plant

A DSM Power Plant can be defined as a group of programmes and projects that reduces electricity consumption and peak loads in a reliable, predictable and measurable manner, so that the resulting energy savings can be compared on an economic, financial, and environmental basis to the power production of a conventional power plant (CPP). Effectively, the results or energy savings of the DSM Power Plant replace power that would have been produced by a CPP. A 100 MW DSM Power Plant, therefore, is equivalent to a potential replacement for a 100 MW CPP [14].

DSM Power Plant aims at up scaling energy efficiency implementation by aggregating a wide range of these options into a single project to achieve a large amount of reduction in peak load and energy consumption at a cost substantially lower than the cost of generating the energy and peak load with conventional generation.

The DSM Power Plant encompasses several elements including energy efficiency, load management and demand response measures under its ambit.

This mega DSM model lends credibility, scale and financial viability to energy efficiency measures.

6. International experience

Large scale implementation of DSM programmes has been undertaken in different parts of the world which could be classified as DSM Power Plant. A brief review of international experience has been undertaken to understand the different approaches being adopted to implement DSM Power Plant in various countries. Table 3 briefly highlights the two key aspects namely; the institutional and financial setup of a DSM Power Plant in various countries.

7. Lessons learned for India

Based on the international review of DSM programs, this section compares each of these international models with the existing energy efficiency scenario in India and highlights the gap which constraints the applicability of these models in case of India. This section also highlights the lessons that can be learnt by India for large scale implementation of DSM in India.

In the California model, the implementer or initiator of DSM was the utility coupled with regulatory push. Most importantly the Californian state policies have a 'loading order' under which energy efficiency is to be taken up on a first priority basis with a combination of policy elements that include aggressive goals based on regular potential studies, performance based incentive mechanisms, robust funding scheme (both through national fund and tariff) and a well-managed monitoring and verification regime. The unifying objective of California's long term energy efficiency policy has been sustained market transformation with increased public awareness [17].The Californian investor utilities currently enjoy incentives in terms of the shared savings model. The Californian model is closest to India as the utility implementation model already exists in India.

However, for the successful implementation of DSM, there is a need to go beyond the utility implementation model. Since most of the utilities are government owned, these are driven more by socio economic objectives unlike so in the case of California; wherein the utilities are run by private entities.

Further, in order to promote DSM, regulators have created DSM fund wherein any expenditure incurred by the utility is allowed as pass through in Annual Revenue Requirement (ARR); however ground level experience reveals no use or minimal use of this fund by the utilities. The DSM programmes initiated by the utilities have been limited to pilot level and have not been replicated on a larger scale.

In the case of New York model, one of the reasons for the successful implementation of energy efficiency programmes was the creation of adequate funds through the levy of tariff surcharge in terms of the 'system benefit charge'. In India, the government already levies electricity duty; but in most cases this fund is not transferred to state due to weak financial situation of utilities or is adjusted against the electricity subsidies with no real outflow of such funds. As per all India estimates, in 2011–12, state electricity duty stood at $ 1.7 billion whereas the tariff subsidy received from state government stood at $ 3.38 billion [4].

In the case of Korea model, Korea Energy Conservation Fund (KECF) has been established through government funding and also there are funds from electricity charge. A separate agency Korean Energy Management Corporation (KEMCO) is responsible for managing and implementation of energy efficiency in the country. In India as per EC Act 2001, every state is required to designate SDAs and create of State energy conservation fund. Even though, Indian states have designated SDAs and created such funds, the agencies created are not adequately equipped with resources in terms of human and financial resources.

In the case of Guangdong model of China, energy efficiency programs have been dependent upon the availability of financial resources from large development banks such as ADB. Access to such resources may or may not be available in India. Given the large potential of energy efficiency in India, DSM needs to be approached as a business model with adequate financial impetus.

The Hebei model of China provides for public private partnership and combines the strengths and capabilities of the public and private partners through the creation of super ESCO. In case of India, Energy Efficiency Services Ltd. (EESL) a super ESCO has already been created by GoI but the adequate utilization of the strength of a super ESCO to attract private sector investments for DSM implementation has not been initiated.

Based on the above review, the key learning from the international cases to the institutional framework of DSM Power Plant in India are as follows:

i. The DSM Power Plant model cannot be entirely dependent on the resource constrained government owned utility for implementation.
ii. DSM cannot be dependent entirely on government funding or government institutions for effective implementation.
iii. Promotion of private sector participation and ESCOs will be key to garnering funds and other resources for effective implementation.
iv. Technical skills up gradation in the government bodies; especially SDAs and utilities are required for effective implementation.
v. Strengthening and capitalizing on the existing resources and institutional frameworks will be crucial to promote energy efficiency in the country.

Table 3
International scenario with respect to DSM Power Plant.

Model	Institutional setup (Implementation agency)	Financial setup (Funding source)
California (Utility implementation with cost recovery)	• Mostly steered by public funding, implementation of EE programs by investor owned utilities and monitored by Californian Public Commission. • California's investor-owned utility's energy efficiency programmes are guided by the Long Term Energy Efficiency Strategic Plan published by the California Public Utilities Commission (CPUC), which outlines a strategic vision of goals focused on market transformation [15]. • The CPUC created an advisory board, the California Board for Energy Efficiency (CBEE), whose mission was to facilitate the selection of an independent administrator and make recommendations regarding utility program designs and budgets to achieve the CPUC's market transformation objectives [16].	• Funding for energy efficiency programs is undertaken through a non-by passable Public Goods Charge (PGC), with the rest is to be recovered through electric rates [15]. • Public Benefits Fund through surcharge of 1.3 mills/kWh [16]. • The California Public Utilities Commission approved energy efficiency funding of $3.1 billion for 2010 through 2012 [15].
New York (Public benefit fund administered by Independent Agency)	• Programme administered by New York State Energy Research and Development Agency (NYSERDA) and investor owned utilities. • MOU has been signed with New York Public Service commission [16]. • The New York Public Service Commission issued Energy efficiency portfolio standard (EEPS) under which several EE schemes have been implemented [17].	• EE programs funded by the 'system benefits surcharge' which is collected by the invertor owned utility as part of the tariff. • Public Benefits Fund through surcharge of 0.83 mills/kWh [16].
Korea (Government funding)	• The Rational Energy Utilization Act mandates the utilities to establish and execute an annual DSM investment plan to improve the efficiency. • Korea Energy Management Corporation (KEMCO) serves as the project management company with regard to the DSM plans. • Under the Improving energy efficiency and reducing energy consumption, by 2030, Korea's goal is to reduce its energy intensity level by 46% [18]. • The utilities invest directly in DSM programmes. Many DSM programmes are actually implemented by ESCOs or vendors of energy efficient equipment [19].	The Korea Electric Power Corporation collects a customer charge equal to 3.7 percent of the electricity charge, which funds the Electric Power Infrastructure Fund and investments in DSM [17]. The Korea Energy Conservation Fund (KECF) has been also established through Government funding and is being managed by Korea Energy Management Corporation.
Guangdong model (Direct consumer funding, including energy savings fee)	The implementing agency for this model is an existing or newly created government agency which is responsible for administering the programme [14].	Individual loans are made to participants. Loan repayment is structured as an Energy Saving Fee (ESF) equal to the average cost per kWh saved for the aggregated DSM Power Plant [14]. Programme is being funded largely by a US $100 million public-sector loan from the Asian Development Bank (ADB).
Hebei model (Public-private partnership)	Joint venture (JV) or a special purpose vehicle (SPV) between a government-created public sector agency (super ESCO) and a private sector partner to take on the implementation responsibility for implementation of the DSM Power Plant projects [14].	Equity funding and debt financing.

vi. Need for policy direction with regard to energy efficiency that provides some mandatory quantitative energy saving targets to be achieved.

8. Proposed framework for DSM Power Plant in India

The section presents the objective of the DSM Power Plant and details out the working mechanism and framework of the DSM Power Plant in terms of policy, institutional and regulatory framework. This section also highlights the role and responsibilities of different stakeholders in the DSM Power Plant model.

8.1. Objectives of the framework

The proposed DSM Power Plant framework aims to meet the following objectives:

i. To upscale the implementation of energy efficiency in the country,
ii. To accelerate the market for energy efficiency by making it more financially viable and attracting investments in a sustainable manner.

8.2. Working of the DSM Power Plant in the Indian setup

The basic premise of the DSM Power Plant model in India is to approach energy efficiency from a resource/supply perspective; very much like a CPP. Thus, energy saved by the energy efficiency schemes under DSM Power Plant is comparable to energy produced by a CPP. One of the major challenges in financing energy efficiency projects is its notional concept. Since energy efficiency is not seen as a product, savings do not imply earnings and this inhibits financing opportunities.

By considering energy efficiency as a resource, twin benefits can be achieved. Firstly, electricity can be delivered at a much lower cost in case of DSM Power Plant vis-a vis CPP. Secondly, the cost incurred in setting up/implementing DSM Power Plant can be recovered in a similar way as in the case of CPP i.e. in the form of a DSM power price (DPP) per kWh of saving achieved from the

consumer, ensuring revenue sustainability of the project and providing clear income stream to investors.

In order to institutionalize DSM Power Plant in India, a multi-stakeholder approach is required. As per the EC Act 2001, SDA is responsible for the implementation of energy conservation activities in the state. The SDA shall be the nodal agency for the implementation of DSM Power Plant in India. In order to provide clear direction to large scale implementation of DSM in India, the respective state government would be required to notify State Energy Efficiency Policy. SDA in consultation with the utilities is required to first undertake an energy efficiency resource assessment study in respective states. Based on this, a group of energy efficiency measures (covering different applications, sectors etc.) can be packaged together to set up a predetermined scale of the DSM Power Plant; say 100 MW. Accordingly, SDA in consultation with SERC would pre-determine the DPP per kWh, based on electricity saving and cost of such a DSM Power Plant. The DPP per kWh thus determined would act as a ball park figure for the investors for such a DSM Power Plant. The investor/ESCO that will implement the energy efficiency schemes would be selected on the basis of competitive bidding and subsequently a tripartite agreement would be signed between investor/ESCO, SDA and utility in the form of an energy service contract. The investor/ESCO on the basis of the potential savings of the given energy efficiency package shall receive monthly payments from the utility at the rate of the decided DPP per kWh. In this model the distribution utilities can pay for the power purchased from DSM Power Plant in the same manner as it does in case of CPP. Since the cost of power purchase from DSM Power Plant would be cheaper, it would benefit the utility by reducing its revenue deficit. The utility shall treat this cost similar to the power procurement cost from other sources of generation and can recover these payments from tariff charge.

The DSM Regulations will obligate the utility to purchase power from the DSM Power Plant in line with the long term targets set under the Energy Efficiency Policy. To determine the savings achieved, monitoring and verification (M&V) procedures would be clearly defined in the Regulations and designated auditors would be appointed for such purposes.

EESL being a super ESCO can play an important role in up scaling the market for ESCO services for the implementation of DSM Power Plant by collaborating with private players and facilitating the creation of a resource pool sufficient to initiate the needed energy efficiency projects.

The Fig. 1 provides a snapshot of the flowchart of the proposed DSM Power Plant model in India. The detailed institutional mechanism along with the role map of each player in the DSM Power Plant model is explained in the next section

8.3. Framework of the proposed model

8.3.1. Step I- State level energy efficiency resource assessment

In order to design and implement a viable DSM Power Plant, potential assessment studies of different energy efficiency measures is imperative at the state level. Potential assessment study will assist DSM activities through provisioning of supporting data of consumer load profile, ownership of appliances, current level of energy efficiency, cost benefit analysis of different measures,

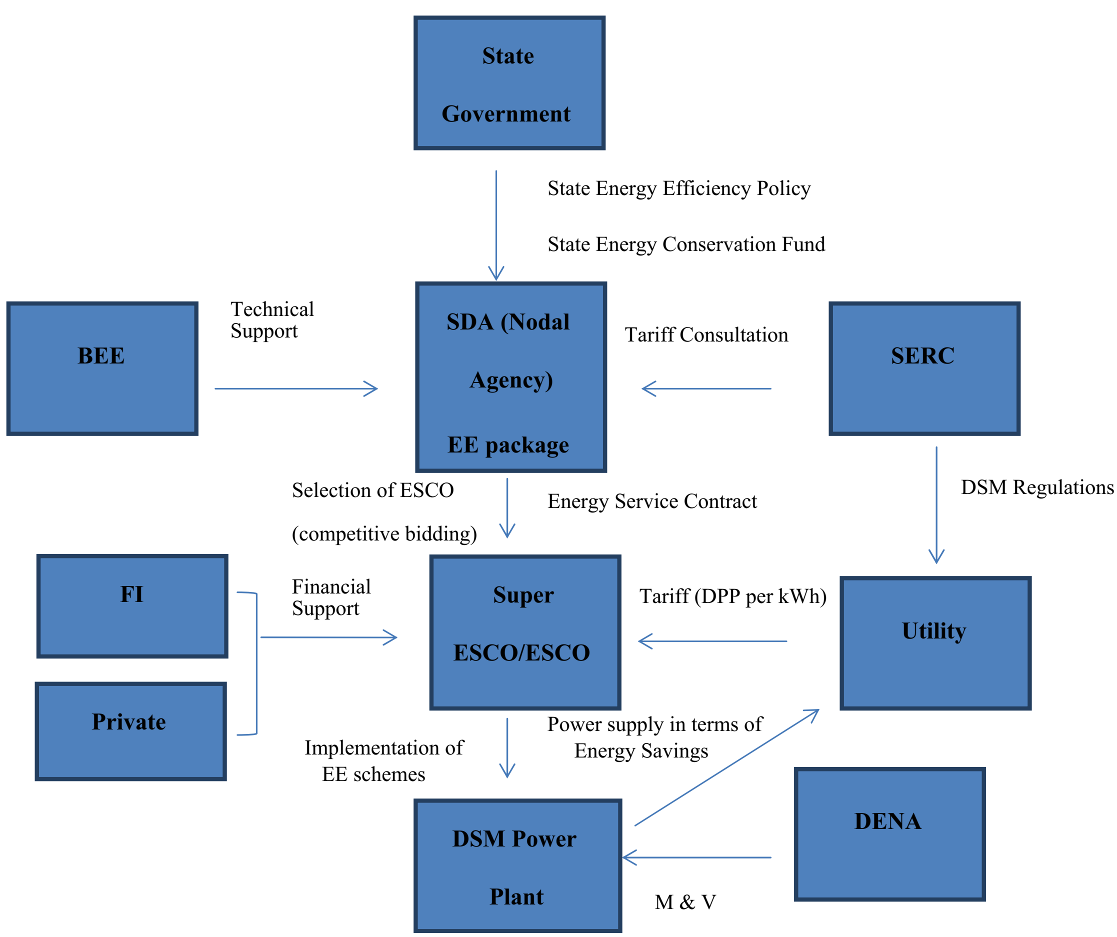

Fig. 1. Framework of the DSM Power Plant model.

potential for peak reduction and improvement of system load factor etc and most importantly the identification of the target sector and pertinent energy efficiency schemes. SDA in collaboration with power utilities shall be responsible for undertaking such assessments.

Also, in order to streamline the process of potential assessment across states, BEE shall be required to provide adequate technical support in designing the framework for research at the state level which can then be used by respective states.

The baseline savings estimated as a part of this study shall be an important determinant for the DPP payment to the investor/ESCO prior to the verification of savings. Since these studies form the basis or act as baseline for all future programmes, it is one of the most crucial stages in the DSM Power Plant model.

8.3.2. Step II- State energy efficiency policy and DSM Regulations

To formalize DSM Power Plant in the state it is important to bring a state energy efficiency policy which will provide the policy framework along with the long term targets and timelin es towards realization of the saving for the implementation of energy efficiency measures based on the potential as assessed in Step 1. The state policy shall also provide for incentive (fiscal/ financial) to the investors/ ESCOs and manufacturers of energy efficiency technology. Further to this, the DSM Regulations drafted by respective SERCs would provide the requisite regulatory framework. The DSM Regulations are required to obligate the utility to purchase power from the DSM Power Plant in line with the long term targets set under the State Energy Efficiency Policy. These Regulations will also lay out M&V protocols that have to be followed for each of the DSM measures under DSM Power Plant.

8.3.3. Step III-Formation and identification of energy efficiency package

In line with the designed policy and regulatory framework, SDA shall design energy efficiency packages under each DSM Power Plant that shall vary with the scale, target consumer group and programme type.

8.3.4. Step IV-Selection of bidder

The investors shall be selected on the basis of competitive bidding. DPP per kWh for each DSM Power Plant will be determined from the bidding process keeping in view the ball park DPP per kWh approved by the SERCs. While calculating the DPP per kWh, the SERCs will account for capital cost and operational costs such as administrative, marketing, employee cost. This reference DPP per kWh is important as it provides an indication to the investor and financial institutions about the risk and return of a DSM Power plant, thus lending credibility to the model.

8.3.5. Step V-Energy service contract

The Energy Service contract will stipulate the terms and condition with respect to the implementation of the DSM Power Plant. The contract will be in form of a tripartite agreement between the SDA, investor/ESCO and the utility. Further, to implement the DSM Power Plant, investor would also be required to sign an agreement with the participating consumers with regard to the appliances installed at their household. This is essential for safeguarding the interest of the investor. The Energy service contract shall also stipulate the terms of payment of the decided DPP per kWh to the investor/ESCO by the utility.

8.3.6. Step VI-Monitoring and evaluation

Designated energy auditors (DENA) shall be appointed by the SDAs and will be carrying out the annual verification of savings of energy efficiency schemes implemented under the DSM Power Plant. M&V protocols shall be provided in the DSM Regulations and shall vary across schemes depending upon parameters such as target type (domestic/ commercial/ industrial/ agriculture), programme type (lighting/HVAC/labeling/audit) etc.

The investor/ESCO under the DSM Power Plant model receives the monthly tariff on the basis of the predetermined savings prior to the verification of the actual savings. Hence regular assessment of savings is important to regularly adjust payments to the investor in the case of over and under achievement from the DSM Power Plant.

8.4. Sustainability of the model

The above mentioned framework is self-sustainable as it provides a win-win situation for all the stakeholders. The sustainability facet of this model for the stakeholders has been described in Fig. 2.

9. Case-study—implementation of a DSM Power Plant in Rajasthan

This section provides an illustration of the DSM Power Plant model described above through a representative state in India using the DSM programmes, namely, replacement of inefficient appliances with efficient ones in the domestic sector. The state of Rajasthan has been taken as a representative state for undertaking this case-study.

9.1. Overview of Rajasthan power sector

The power sector in the state is dominated by state owned power utilities. In accordance with the power sector reforms, in 2000, erstwhile Rajasthan State Electricity Board (RSEB) was unbundled into five successor entities; Rajasthan Vidyut Nigam (RVUN) responsible for generation, Rajasthan Prasaran Vidyut Nigam (RVPN) responsible for transmission and three distribution companies Jaipur Vidyut Vitaran Nigam (JVVNL), Ajmer Vidyut Vitaran Nigam (AVVNL) and Jodhpur Vidyut Vitaran Nigam (JdVVNL). Rajasthan Electricity Regulatory Commission (RERC) was formed alongside as overarching body to regulate the functioning of the utilities under the Rajasthan Power Sector Reform Act, 1999 and Electricity Act, 2003.

In addition, Rajasthan Renewable Energy Corporation (RREC) is responsible for energy conservation and renewable energy development in the state.

9.2. Need for energy efficiency in Rajasthan

The power sector in Rajasthan is characterized by high energy and peak shortages, inadequate capacity additions, increasing gap between average revenue realization and average cost of supply and high accumulated financial losses, necessitating the need for implementing DSM in the state. In 2011–12, the energy and peak shortages stood at 3.9% and 7.1% respectively [3]. The total accumulated deficit/losses of distribution utilities as on 31st March 2011 were estimated to be around $ 4 billion [20]. The primary reason for the financial deterioration of the utility has been the increasing gap between average cost of supply and average revenue realization, attributed to the non-revision of tariffs in Rajasthan for several years. In 2011–12, there was a gap of cents 2.70/kWh [20] between average revenue realization and

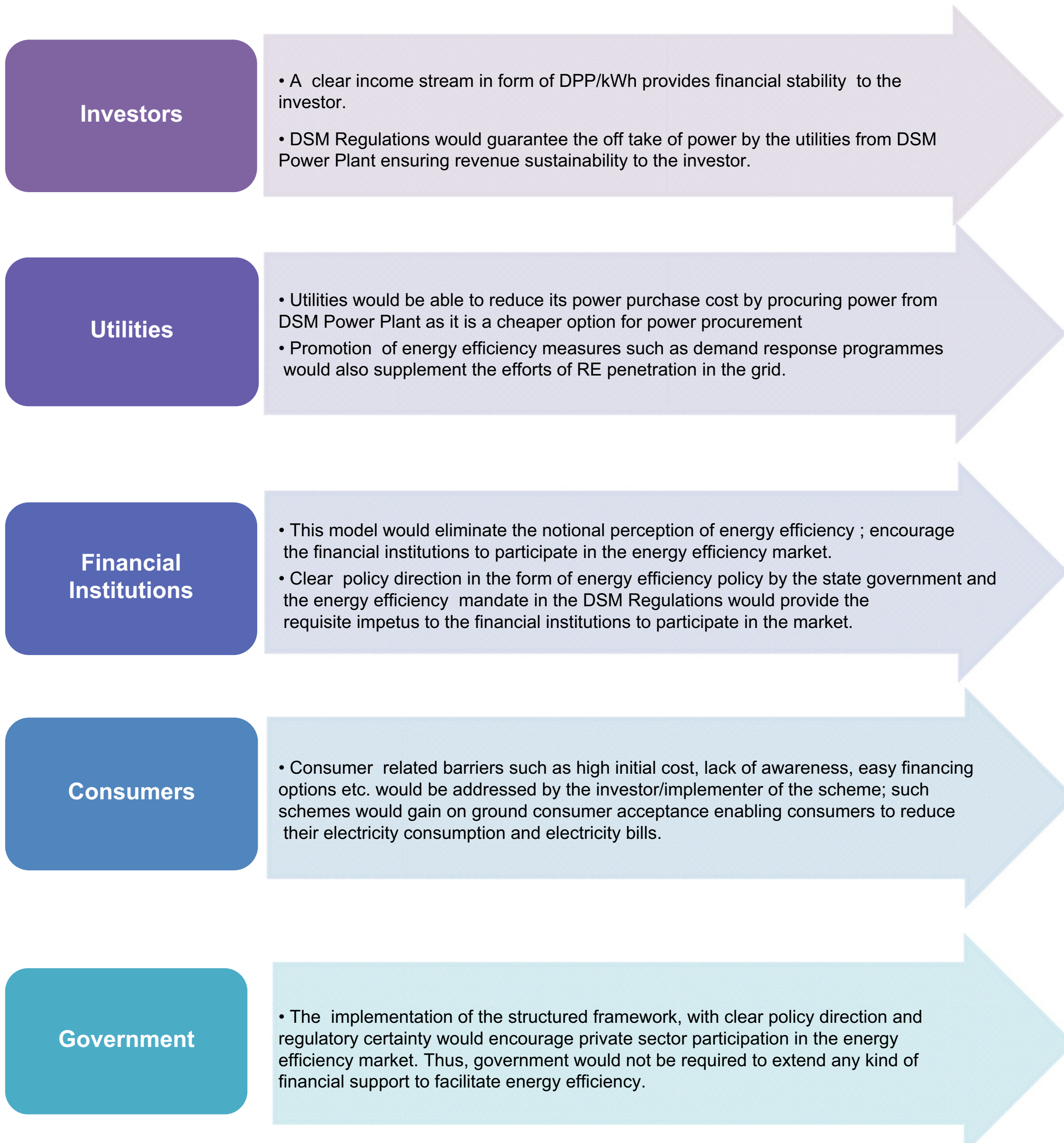

Fig. 2. Sustainability of the DSM Power Plant model.

average cost of supply. Further, domestic and agriculture categories have been heavily cross-subsidized by the industrial and commercial categories in Rajasthan.

9.3. Framework of DSM Power Plant in Rajasthan

9.3.1. Institutional framework

The representative DSM Power Plant in Rajasthan comprises the scheme of large scale replacement of inefficient appliances in the domestic sector. This illustrative DSM Power Plant has a scale of 100 MW with a configuration of replacement scheme for 0.25 million domestic households. The energy efficient appliances scheme for each household includes replacement of two T12 tube light with T5 tube light, two inefficient ceiling fans with efficient ceiling fans, one non-star AC with 5 star AC and one non starred refrigerator with 5 star refrigerator.

The Fig. 3 provides institutional setup of a DSM Power Plant in Rajasthan. The next sections discuss the financial framework of the DSM Power Plant.

9.3.2. Generation from the DSM Power Plant

Generation from the DSM Power Plant is the energy savings from the replacement scheme under this project. The appliance wise energy savings per household is provided in the Table 4. The annual generation for the DSM Power Plant is the aggregate energy savings for the 0.25 million households under this programme.

Annual generation projections for the DSM Power Plant during its life along with the capacity avoided (scale) are provided in Table 5 and the methodology for computation of DPP per kWh from the DSM Power Plant is provided in Table 6.

9.3.3. Computation of capital cost

The total capital cost for the scheme for 0.25 million households under this 100 MW DSM Power Plant is $ 57 million. The capital cost of the DSM Power Plant as discussed above is the cost of the energy efficient appliance replaced borne by the investor over and above the cost to the consumer. The details of the computation of capital cost are provided in the Table 7.

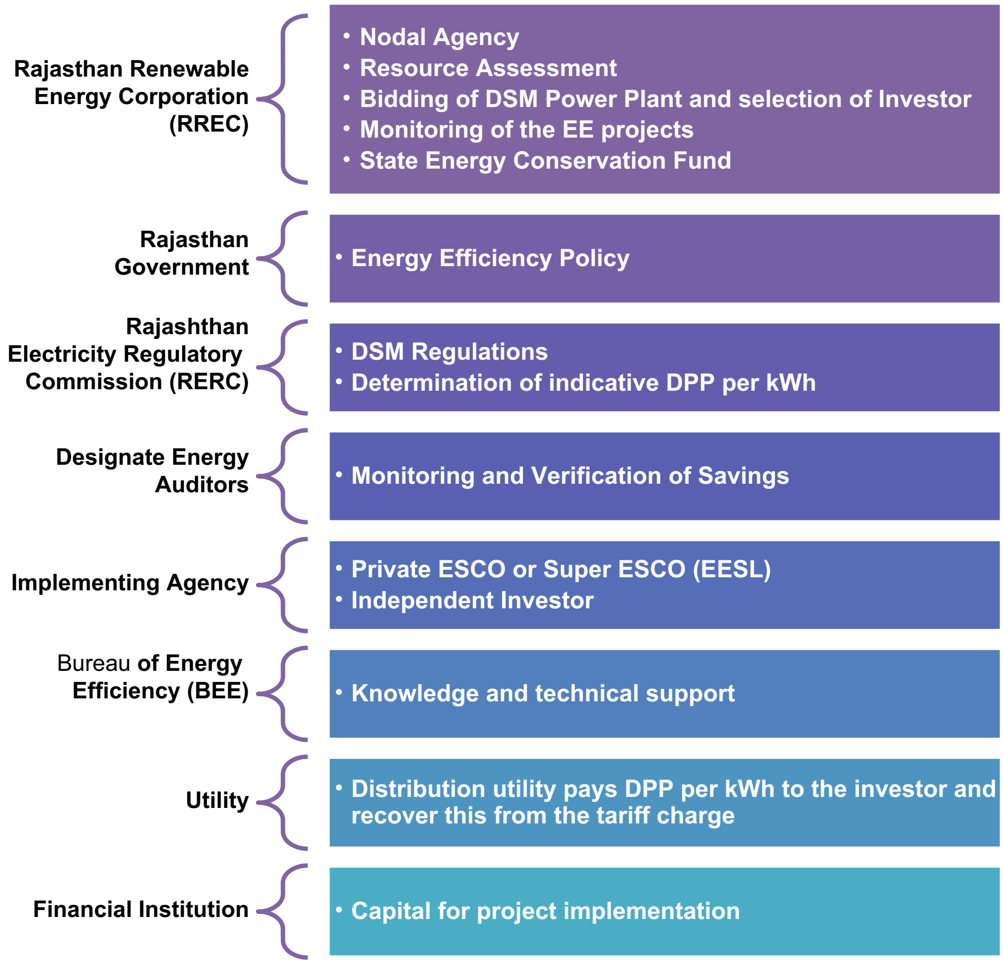

Fig. 3. Institutional setup of a DSM Power Plant in Rajasthan.

Table 4
Appliance wise energy savings per household.

Intervention	Usage pattern (Assumptions)	Appliances replaced in a household	Savings per household (kWh)
Replacement of T-12 tube light with copper choke (55 W) withT-5 tube light	10 h/day for 365 days a year	2	175
Replacement of inefficient ceiling fan (75 W) with efficient (50 W) ceiling fan	12 h/day for 240 days in an year	2	144
Replacement of inefficient AC (2570 W) with efficient AC (1600 W, for 5 star)[a]	10 h/day for 180 days in an year	1	1222
Replacement of inefficient Refrigerator (annual energy consumption of 1100 kWh) with efficient 5 star Refrigerator (annual energy consumption of 400 kWh)	24 h/day for 365 days a year	1	700

[a] Assumed a diversity factor of 0.7.

Table 5
Generation of the DSM Power Plant.

Appliance/Year	1	2	3	4	5
Tube light (GW h)	43.80	43.80	43.80	43.80	40.80
Fans (GW h)	36.00	36.00	36.00	36.00	36.00
AC (GW h)	305.55	305.55	305.55	305.55	305.55
Refrigerator(GW h)	175.00	175.00	175.00	175.00	175.00
Total (GW h)	**560.35**	**560.35**	**560.35**	**560.35**	**557.35**
T&D losses (%)[a]	25	24	23	22	21
Total generation (GW h)	**700.44**	**694.83**	**689.23**	**683.63**	**674.39**
Capacity avoided/Scale (MW)	**100**	**99**	**98**	**98**	**96**

[a] T&D loss trajectory as per the Multi Year Tariff Order of RERC.

The total annual cost spread over the life of the DSM Power Plant taking into the account the various cost parameters and the DPP per kWh are provided in the Table 8.

In the case of the DSM Power Plant in Rajasthan, the DPP per kWh comes out to be cents 2.95 that is lower as compared to the CPPs in Rajasthan namely Ramgarh gas thermal power station (RGTPPS), Kota thermal power station (KTPS), Suratgarh supercritical thermal power station (SSTPS) and Dholpur combined cycle gas power station (DCCPP). The comparison of the DPP per kWh of a DSM Power Plant and the tariff of the CPPs in Rajasthan is provided in the Table 9 [21].

9.3.4. Impact of the DSM Power Plant on distribution utilities of Rajasthan

The genesis of this entire concept of DSM Power Plant lies in the fact that it benefits the utility in reducing its power purchase cost thereby improving revenue and reducing the revenue deficit. By procuring power from DSM Power Plant at DPP per kWh of cents 2.95, the distribution utilities of Rajasthan are reducing their revenue deficit in 2011–12 by 2.98%. In order to estimate the

Table 6
Methodology for computation of DPP per kWh.

In order to compute DPP per kWh, the following assumptions have been considered for the computation of cost and return:

a) Life of DSM Power Plant—The life of this DSM Power Plant has been considered as 5 years as it is a reasonable time period for the investor to recover its capital.
b) Capital cost of the DSM Power Plant—Under this scheme, efficient appliances are provided to the consumer at the cost of the inefficient ones. The capital cost of the project is the differential in the actual price and the price paid by the consumer for the efficient appliances.
c) Debt equity ratio—Debt equity ratio has been considered as 70:30 in line with the RERC Tariff Regulations 2009.
d) Return on equity—The return on equity has been computed on pre-tax basis at the base rate of 15.5% in line with the RERC Tariff Regulations 2009.
e) Depreciation—Depreciation of capital for the DSM Power Plant model has been computed on the basis of straight line method. Equal rate of depreciation has been considered for the entire life of the project.
f) Interest on loan—The interest rate has been assumed as per the current prime lending rate. The average balance has been considered to compute the interest amount and the repayment has been pegged at the allowed depreciation in line with the RERC Tariff Regulations 2009.
g) Operational costs—The operational costs primarily include marketing, administrative and general and employee costs.
    i. Marketing costs include marketing and promotion of the energy efficiency appliance schemes under the DSM Power Plant model and has been assumed as 2% of the capital cost.
    ii. Administrative &general expenses and employee cost and has been assumed as 2% of the capital cost. Annual escalation of 5.72% has been considered for these expenses.

Table 7
Computation of capital cost of DSM Power Plant.

Intervention	Cost of energy efficient appliance ($)	Cost to Consumer per appliance ($)	Cost to Investor per Appliance ($)	Appliances replaced in a household	Cost to Investor per Household ($)	Total Cost to Investor for project ($ Million)
Replacement of T-12 tube light with copper choke (55 W) withT-5 tube light	7.7	2.9	4.8	2	9.6	2.4
Replacement of inefficient ceiling fan (75 W) with efficient (50 W) ceiling fan	28.7	15.3	13.4	2	26.8	6.7
Replacement of inefficient AC (2570 W) with efficient AC (1600 W, for 5 star)*	536.3	383.1	153.2	1	153.2	38.3
Replacement of inefficient Refrigerator (annual energy consumption of 1100 kWh) with efficient 5 star Refrigerator (annual energy consumption of 400 kWh)	306.5	268.2	38.3	1	38.3	9.6
Total	879.2	669.5	209.7		227.9	57

Note: Exchange rate (1$= Rs 52.2) has been considered as per average of first 6 months of 2012.

* 5 star is the most efficient star rating and the level of efficiency reduces from 5 star to 1 star.

Table 8
Total annual cost of DSM Power Plant.

Particulars	Unit/Year	1	2	3	4	5
Marketing cost	$ Million	1.14	1.14	1.14	1.14	1.14
Employee cost	$ Million	1.14	1.20	1.27	1.35	1.42
Administrative and general expenses	$ Million	1.14	1.20	1.27	1.35	1.42
Depreciation	$ Million	11.40	11.40	11.40	11.40	11.40
Interest on term loan	$ Million	5.04	3.36	1.68	0.42	0.00
Return on equity	$ Million	3.25	3.25	3.25	3.25	3.25
Total cost	$ Million	23.11	21.56	20.02	18.90	18.63
DPP per kWh (cents)		3.26	3.07	2.87	2.68	2.68
Discount factor		1	0.9	0.8	0.7	0.7
Levelized DPP per kWh (cents)	**2.95**					

Table 9
Cost per kWh - DSM Power Plant v/s CPP in Rajasthan.

Characteristics	DSM Power Plant	RGTPPS	KTPS	SSTPS	DCCPP
Capacity (MW)	100	110	1240	1500	330
Type of plant		Gas based	Coal based	Coal based	Gas based
Total cost/kWh (cents)	**2.95**	**5.76**	**5.72**	**7.07**	**5.76**

impact of the DSM Power Plant, the parameters considered have been provided in the Table 10.

The illustration above considers only appliance replacement programme in the domestic sector under the ambit of the considered DSM Power Plant. Similar DSM Power Plants can be designed to include several energy efficiency measures/application ranging across consumer categories based on the resource assessment study in the state.

10. Conclusion

The DSM Power Plant has a myriad of advantages that is required to give energy efficiency the much deserved impetus in the Indian setup. Energy efficiency in India has so far been the prerogative of the utilities. However, impending financial burden on the utilities and the notional concept of energy efficiency have impeded the requisite investment in the energy efficiency market

Table 10
Monetary Benefits of DSM Power Plant in Rajasthan.

Particular	Units	FY 2011-12
Units generated in year 1	GW h	700
Yearly revenue loss due to reduced sales in the domestic sector	$ Million	51.3
Yearly revenue gain due to increased power availability to all consumer categories in equal proportions[a] at the respective average tariff[b]	$ Million	64.7
Net yearly gain in revenue	$ Million	13.4
Average power purchase cost in Rajasthan	$/kWh	0.1
DPP per kWh	cents/kWh	2.95
Net Decrease in power purchase cost in Rajasthan	$ Million	19.7
Net benefit to the utility	$ Million	33.1
Revenue deficit upto FY 2011–12	$ Million	1113.2
% Decrease in revenue deficit	%	2.98%

[a] Since Rajasthan is an energy deficient state, it is expected that power available from DSM Power Plant will increase power availability to all consumer categories (except agriculture as its consumption is rostered in Rajasthan).
[b] Average tariff (Domestic- cents 7.32/kWh, Industrial- cents 9.35/kWh, Commercial-cents 11.07/kWh).

despite its cost effectiveness. The DSM Power Plant model moves away from utility dependence and provides a significant market size/scale to participating investor/ESCO.

The DSM Power Plant is envisaged as a win-win model for all the stakeholders. The benefit to the consumer lies in the fact that it enables purchase of efficient appliances thereby leading to reduction in their electricity consumption and electricity bills while also extending savings to the utilities in terms of low cost power procurement. Further, guaranteed flow of income through DPP ensures financial sustainability and certainty to the investors. It is expected that this model will help up-scaling energy efficiency programmes by mobilizing private sector resources to energy efficiency.

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